Sensitivity of HWRF Simulations to Parameter Variations in the Grell-Freitas Convection Scheme

E. Grell\(^1,2\), M. Biswas\(^2,3\), G. Grell\(^4\), E. Kalina\(^2,5\), K. Newman\(^2,3\), L. Bernardet\(^2,5\), L. Carson\(^2,3\), J. Frimel\(^2,4,6\)

\(^1\)University of Colorado Cooperative Institute for Research in Environmental Sciences at the NOAA Earth System Research Laboratory/Physical Sciences Division
\(^2\)Developmental Testbed Center
\(^3\)National Center for Atmospheric Research
\(^4\)NOAA Earth System Research Laboratory/Physical Sciences Division
\(^5\)University of Colorado Cooperative Institute for Research in Environmental Sciences at the NOAA Earth System Research Laboratory/Global Systems Division
\(^6\)Colorado State University/Cooperative Institute for Research in the Atmosphere, Fort Collins, CO

Motivation

In preparation for the next hurricane season, testing of alternative physics modules in the HWRF model is routinely done, in an effort to improve the hurricane forecasts. One alternative physics scheme that was tested recently is the Grell-Freitas (GF) convection parameterization (Grell and Freitas 2014, ACP). This scheme is scale- and aerosol-aware, and is currently being used operationally in several models (RAP, BRAMS). In the HWRF model, with a different set of physics parameterizations, initial test results did not yet lead to improved performance compared to the current operational convection parameterization, the scale-aware SAS scheme.

When bringing a new physics parameterization into a physics suite, tuning of the scheme is often required to make the scheme work well with the other parameterizations. In an effort to identify possible ways to improve the interaction and performance of the GF scheme for potential future use in HWRF, experiments were performed to test the sensitivity of the hurricane simulations to certain parameter variations within the GF scheme. These parameters impact a) the distribution of the mass flux, b) the convective momentum mixing, c) inclusion of ice physics, and d) the magnitude of the cloud water detrainment. Here, results are shown for a single simulation of Hurricane Maria.

The GF scheme includes:

- DEEP CONVECTION:
  - CAPE, vertical velocity and moisture convergence closures
  - Scale-awareness through Arakawa (2011) approach
  - Momentum transport as in GFS/SAS or ECMWF
  - Diurnal cycle effect

- SHALLOW CONVECTION:
  - Autoconversion of cloud water to rain water has been modified since 2014 paper
  - Leading to smoother vertical profiles, and allowing for easy application of stochastic perturbations
  - Inversion detection routine to determine cloud top heights for shallow and mid-level convection
  - Autoconversion of cloud water to rain water has been modified since 2014 paper

- MIXING:
  - Modified convective momentum mixing. Stronger entrainment of momentum=weaker impact of momentum flux
  - Weaker entrainment of momentum in updraft

- MASS FLUX DENSITY:
  - Modified mass flux distribution profile – max is lower

The HWRF Model

- WRF-NMM dynamic core
- \(\Delta x=18, 6, \) and 2 km
- Storm-following nests
- 75 vertical levels
- Ocean coupling (POM)
- Microphysics: Ferrier-Aligo
- Radiation: RRTMG
- NOAH LSM surface
- GFDL sfc layer
- Storm-following nests
- NOAA NWP convective parameterization
- Diurnal cycle effect

For comparison: GFctrl vs H8SS